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MINING METHODS AND COSTS AT THE GROUND HOG UNIT, ASARCO MINING CO., VANADIUM, NEW MEXICO

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F. W. RICHARD

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MINING METHODS AND COSTS AT THE GROUND HOG UNIT, ASARCO MINING CO., VANADIUM, NEW MEXICO[1]

By F. W. Richard[2]

INTRODUCTION

This paper describing the mining practices at the Ground Hog Unit of the Asarco Mining Co., a subsidiary of the American Smelting and Refining Co., is one of a series being prepared by the United States Bureau of Mines on mining methods, practices, and costs in the various mining districts of the United States.

The Ground Hog mine is at Vanadium in the Central mining district, Grant County, N. Mex., about 10 miles east of Silver City and $2\frac{1}{2}$ miles southwest of Santa Rita. A branch line of the Atchison, Topeka & Santa Fe Railway connects Vanadium with Deming, about 45 miles southeast.

The current production of the mine is about 130 tons per day of lead-zinc-copper ore, requiring the employment of about 100 men underground and on the surface. This ore is treated at a custom mill at Deming and the concentrates are smelted at the El Paso smelter of the American Smelting and Refining Co. The average grade of the mill ore is 6.5 ounces of silver per ton, 8.0 per cent lead, 3.5 per cent copper, and 15 per cent zinc.

Stoping methods in use include square-setting and filling, both horizontal and rilled, untimbered filled rill stopes, and to a slight extent, horizontal filled stopes using stulls for temporary supports. These methods have been adapted to the ground condition encountered and in the ore body now being mined have proved satisfactory.

ACKNOWLEDGMENTS

Assistance in preparing this paper has been received from Julius Kruttschnitt, jr., manager, Milner Hawkins, mining engineer, R. M. Twiss, accountant, and A. A. Arluck, mine foreman, of the Ground Hog Unit, and C. H. Johnson, assistant mining engineer of the United States Bureau of Mines.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6377."

[2] One of the consulting engineers, U. S. Bureau of Mines, and superintendent, Ground Hog Unit, Asarco Mining Co.

HISTORY

The copper mines at Santa Rita were worked by the Spaniards as long ago as 1801. The San Jose claim, on the same vein as the Ground Hog and adjoining it at the north, was located in 1875 and patented in 1900. The outcrop on the Ground Hog claim was mostly covered with overburden and the exposed portions were barren quartz, so that as a result this claim was not located until 1900; it was patented in 1913. Up to 1917 the net smelter return of shipments from the Ground Hog was about $50,000, derived from lead-copper ores encountered about 100 feet below the surface at the south end of the claim.

The mine was sold in 1917 and from then until February, 1920, when shipments ceased due to the temporary closing of the smelters, 6,430 tons of lead-copper carbonate and sulphide ore was produced which netted at the smelter over $212,000; this ore was sold at war-time metal prices. During this period the present two-compartment shaft was sunk to below the 300-foot level and the property was equipped with a gasoline hoist and a compressor. The mine was then idle until the fall of 1924, when it was taken under option by the Hayward-Richard Leasing Co., a partnership. The leasing company deepened the shaft to the 400 level, crosscut to the vein and explored it to the south on that level. Some small and irregular ore bodies were found and stoped as soon as exposed; as much as 500 tons of ore was seldom in sight. This condition required that a large amount of development work be done to keep in ore. Stoping was by means of open stulled stopes, without filling. The production by the leasing company, from the fall of 1924 to June 1928, was 30,012 tons of lead and copper ore. This ore was of three classes: Lead carbonate ore with a little copper and silver, lead and copper sulphide ores carrying some silver, and secondary copper ore.

In the spring of 1928, after drifting north on the 400-foot level through a long barren zone, a 3-inch stringer of sulphide was encountered which, after 65 feet of further drifting, was intersected by a cross-fracture and opened into a good-sized ore body. This ore body was distinctly different from those previously found, and consisted of primary sulphides of lead, zinc, and copper. As development progressed it proved larger and more continuous than any other ore body along the vein. However, owing to the complex nature of the ore the leasing company was unable to market it, and in June, 1928, a 51 per cent interest in the property was sold to the American Smelting & Refining Co. Since then the production has been 45,309 tons. The milling has been done at the custom mill of the Peru Mining Co., a subsidiary of the Illinois Zinc Co., situated at Wemple, about 3 miles north of Deming on the Atchison, Topeka & Santa Fe Railroad.

GEOLOGY

The lead-zinc mines of the Central mining district are mostly in limestone. To the present time no other ore body similar to the Ground Hog has been found in the district. Before the extrusion of the Tertiary volcanoe (fig. 1) the ground now containing the ore bodies was severely faulted, developing a series of parallel fractures having a general northeasterly strike and a dip of about 50° to the southeast. Subsequent to a part of this faulting came the intrusion of quartz diorite porphyry and granodiorite, the latter known locally as "bird's-eye porphyry," probably in the form of dikes which followed the fault zone. More faulting along old planes of weakness followed. Apparently subsequent intrusions have consisted of siliceous and ore-bearing solutions.

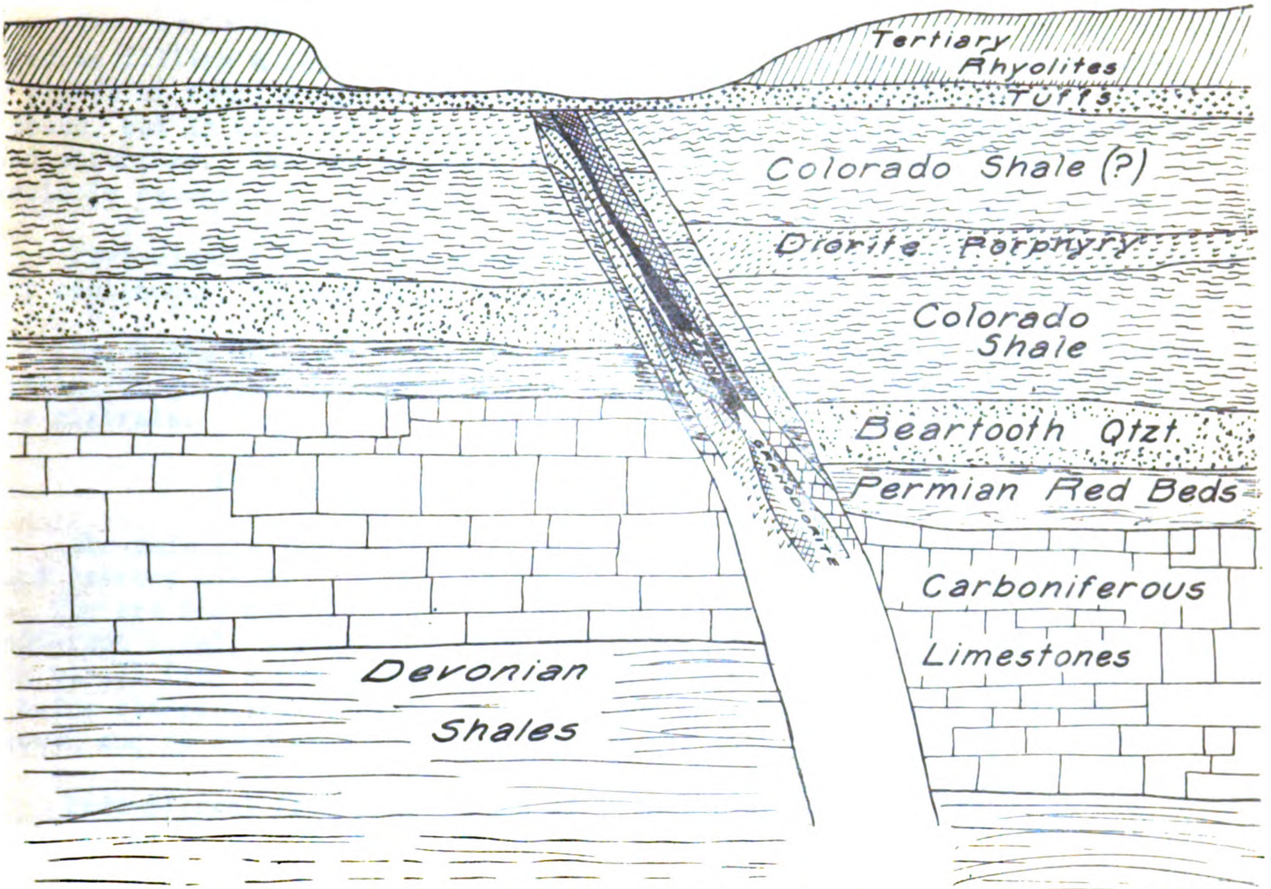


Figure 1.- Theoretical geological section

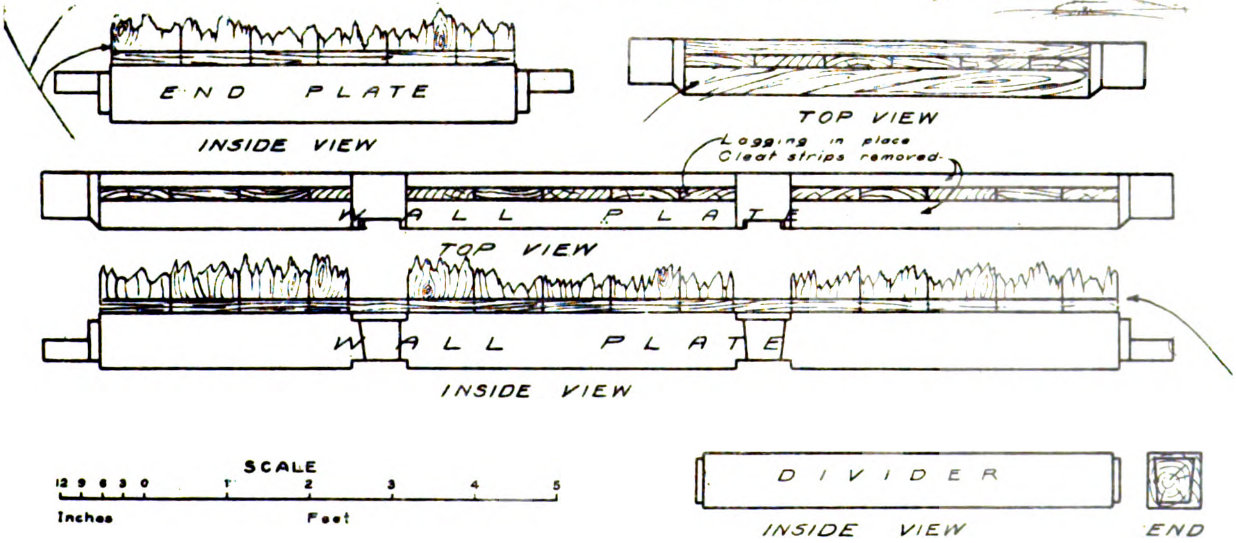


Figure 2.- Framed shaft set

The result of these events has been to form an ore body which may be considered as filling a fault fissure. It has foot and hanging walls consisting in many places of fault gouge several feet thick. In some places the vein is very siliceous, but in most parts it is massive sulphide. The ore presents a roughly banded structure. The ore minerals do not extend into the wall rocks to any appreciable extent.

Post-mineral faulting has not been found to be extensive, and the vein is fairly continuous, without major displacements.

Below the 400-foot level the mineralization is practically all primary, consisting of galena, chalcopyrite, and sphalerite, with quartz and pyrite as gangue minerals.

PHYSICAL CHARACTERISTICS OF ORE AND WALL ROCKS

The main ore shoot occurs as irregularly shaped connected lenses along the contact between the diorite porphyry and a granodiorite or "bird's-eye porphyry" dike. The ore has been followed for approximately 600 feet along the strike on the 500-foot level, and extends from that level to the 300, where it apexes. Its width varies from 3 feet to 25 feet normal to the dip. The average dip is about 50°, being steeper than that at the north end of the claim and flattening toward the south end to such an extent that broken ore will not run freely by gravity.

Post-mineral faulting, though of slight displacement, has fractured the ore and wall rocks so that they make treacherous mining ground, which must be studied carefully and watched closely to prevent disastrous cave-ins. The ore is a heavy sulphide of little natural strength, and in general requires more support than do the walls. The dike forming the hanging wall in most places is from 15 to 90 feet thick. It will stand if not opened over too great distances; if too large an area is unsupported it breaks into large slabs or blocks. The footwall consists normally of a thick gouge, which may cause trouble by sloughing away, thus weakening the back and increasing the amount of waste to be handled. Frequently, however, the vein material next to the footwall consists of a low-grade siliceous ore which can be left in place, and which forms a strong and satisfactory wall.

Perhaps the worst condition occurs where the vein has formed in the diorite slightly removed from the dike. The thin shell of diorite then forming the hanging wall, being badly fractured and crushed, is very difficult to support. It has a tendency to "ravel" away from the edge of a block or stull headboard, and requires close and prompt filling.

PROSPECTING AND EXPLORATION

Prospecting on the lower levels has been confined to drifting and sinking on the vein. On the 300-foot level there has been considerable crosscutting to the foot and hanging walls, the waste from this work being used for fill in stopes below. Similarly, as stoping has advanced on the 500 level, crosscutting has started on the 400. The ore has been developed for a length of 600 feet on the 500-foot level, but no crosscutting beyond the limits of the ore has yet been done on this level. No prospect drilling has been done.

SAMPLING AND ESTIMATION OF TONNAGES AND VALUES

Samples are cut by hammer and moil in all drifts and crosscuts. Channels 3 inches wide by about 1 inch deep are cut across the vein at 5-foot intervals. In crosscuts the channels are cut about 3 feet above the floor; at every 5 feet a sample is taken. Raises are not sampled.

Tonnage and grade are calculated for each block, the blocks being defined by main levels and sublevels, about 65 feet apart on the slope of the vein, or 50 feet vertically, and by raises between levels, which are 50 feet apart along the strike. The average area of the top and bottom of the block, normal to the dip, multiplied by the length of the block along the strike, gives the volume of the block. A factor of 9 cubic feet per ton is used to convert volume to tonnage. An average assay value of the ore in each block is obtained by multiplying the width of the ore at each sample cut by the average assay of the cut, and dividing the sum of all such products by the sum of all the widths.

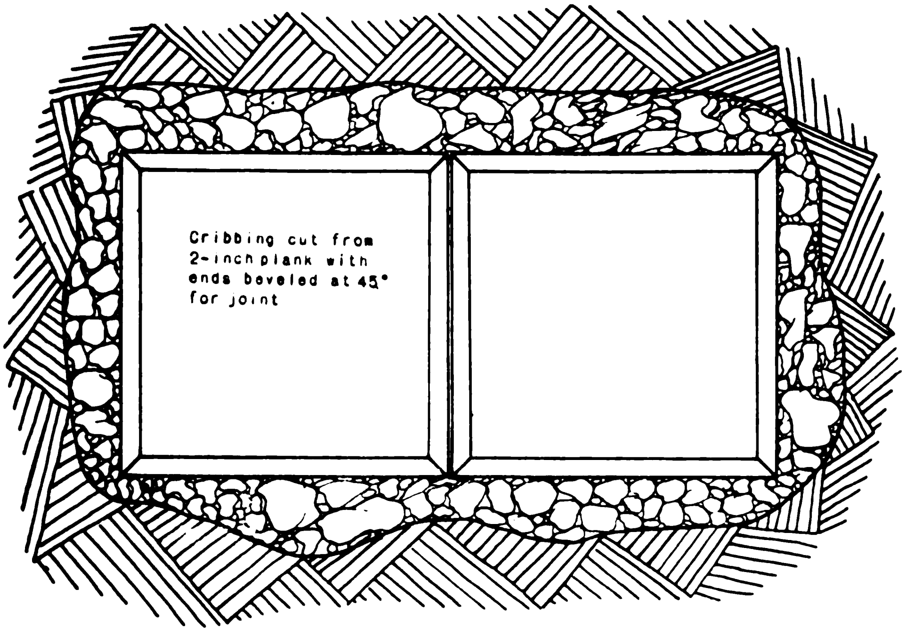
Experience to the present time has shown that this method of estimating gives results which are too high in assay values and too low in tonnages. One reason for the high assays is that the sublevels are driven close to the hanging wall, where the best ore is concentrated, and not opened over the full width of the vein, as are the main levels. An explanation of the low estimated tonnages is that in stoping, a considerable amount of low-grade ore is mined from the footwall. About 25 per cent more ore is mined than is estimated, and the grade is correspondingly lower.

Close sampling is not necessary for operating purposes because the grade is easily estimated by eye by experienced men. Samples therefore are taken only from doubtful ore as it is encountered in drifting or stoping. Production samples are obtained daily. These are taken at the collar of the shaft and consist of a small shovelful from each car hoisted, combined into one sample for each shift. Mill ore samples are assayed for zinc in the mine assay office and smelting ore samples are assayed for lead and copper.

METHODS OF DEVELOPMENT AND MINING

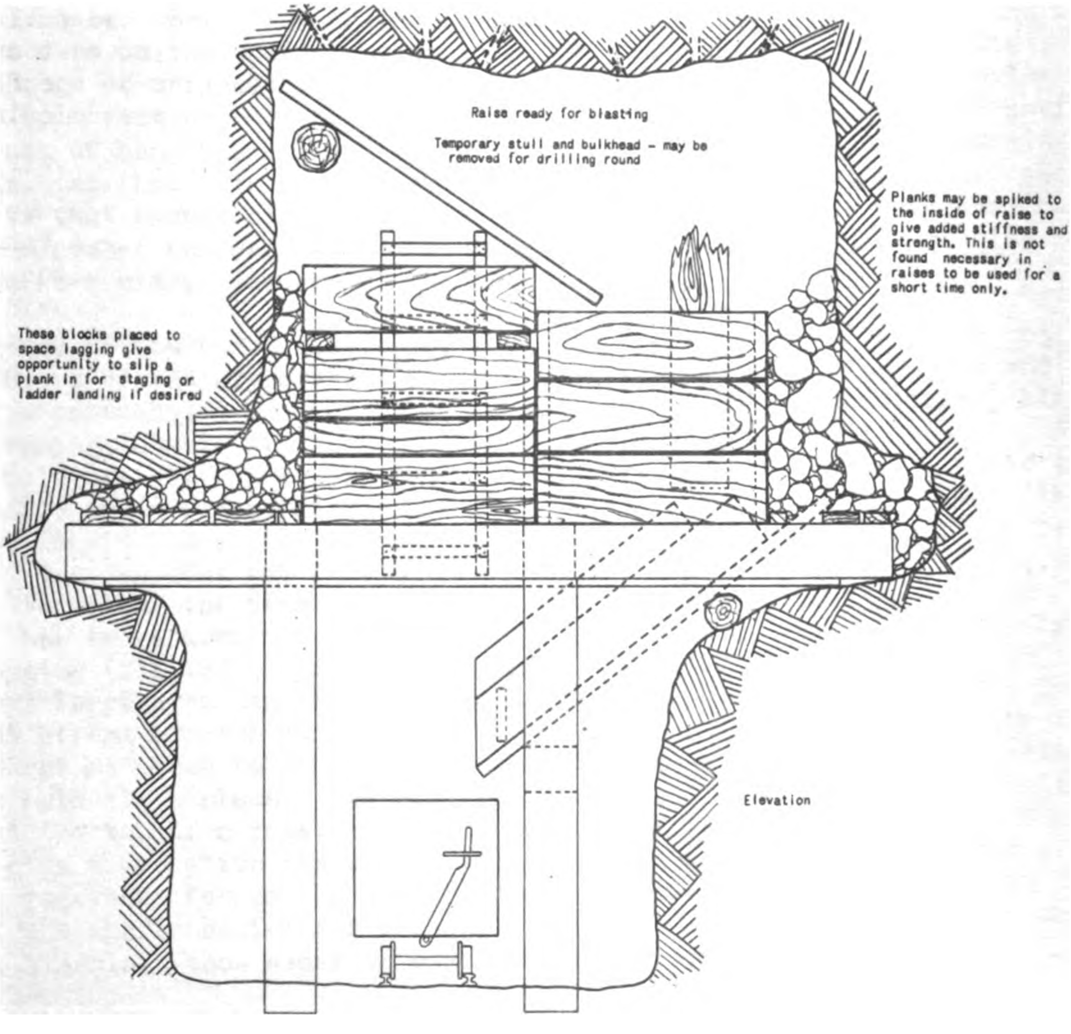
General development

The Ground Hog mine is operated through a two-compartment vertical shaft 400 feet deep. This shaft starts in the hanging wall and intersects the vein at the 300 level. At the 400 level a crosscut has been driven to the vein, a distance of 160 feet. At the south end of the ore shoot a two-compartment, 42° inclined winze has been sunk a distance of 170 feet down the vein from the 400 level. The 500-foot level has been driven from this winze, at a distance of 140 feet from the 400 level. At present 75 per cent of the ore produced is mined on the 500 level and hoisted to the 400 level, where it is trammed a distance of about 700 feet to the main shaft and hoisted to the surface.



Cribbing cut from 2-inch plank with ends beveled at 45° for joint

Figure 3.- Details of shaft raise



Raise ready for blasting

Temporary stull and bulkhead - may be removed for drilling round

Planks may be spiked to the inside of raise to give added stiffness and strength. This is not found necessary in raises to be used for a short time only.

These blocks placed to space lagging give opportunity to slip a plank in for staging or ladder landing if desired

Figure 4.- Timber construction at bottom of shaft raise

Development in the ore consists of drifting on the main levels and sublevels. Main levels are about 100 feet apart vertically and the sublevels halfway between, giving 65 to 70 feet of vein from the floor of the main level to the floor of the sub. The sublevels are untimbered, except in a very few places. They are never used for starting stoping operations, but have been found very convenient in distributing filling. Their chief advantage, however, is that they shorten the length of raises to about 65 feet, instead of 135 to 140 feet. These raises are spaced at 50-foot intervals along the vein, for ore and waste passes. They also help to drain and ventilate the blocks.

Development Details

Shaft Sinking

The main shaft has two compartments each 4 feet by 4 feet 6 inches in the clear. It is timbered with 8 by 8 inch timbers of local pine, except that the centers or dividers are 6 by 8 inches in size. When this shaft was sunk, no center posts were placed, and only enough hanger bolts were used to hold the last few bottom sets, although it passes through some very soft ground where it intersects a fault zone. Several years ago a stope caved in near the shaft, and when the pressure came on the shaft it crushed a corner-post end that was rotted. This movement, though of only about 3 inches, was enough to start all sets moving through the soft section, and the cave travelled about 75 feet before it could be stopped. Lack of hanger bolts and center posts was responsible for extending the movement far. At that time hanger bolts were placed throughout the heavy section, and all posts that showed signs of rot were "doubled." In 1928, when the change was made from bucket and cross-head hoisting to cage hoisting, hanger bolts and center posts were placed throughout the shaft.

Because of the bad condition of this shaft, a new shaft is being put down at the north end of the property. This will be timbered with Oregon fir and will have three compartments - two for hoisting and one for manway and pipes. Figure 2 shows the framing details of the shaft timbers. The shaft is being sunk by first putting up pilot raises. A crosscut has been driven on the 300 level under an old prospect shaft, and a two-compartment cribbed raise driven to connect with the bottom of the shaft. A similar procedure has connected the 400 to the 300 level, and crosscutting is under way on the 500 level to reach the location of the shaft preparatory to making the final connection. The cribbed raise used in this development has two-compartments, each 3 by 3 feet inside, timbered with 2 by 10 inch fir lagging (fig. 3). This type of raise timbering has been very satisfactory It uses short lengths of lagging, the individual pieces are easy to handle and place, tight strong manways and chutes are obtained, and in soft ground the raise can be timbered as close to the face as desired. Broken rock is packed behind the cribbing to hold it in place. The cribbed raise is finally enlarged to shaft size, beginning at the top of a section. Only enough cribbing is removed for one slabbing round at a time, which tends to prevent overbreak. About 75 per cent of the cribbing is recovered for use in other sections of the shaft raises. Final trimming of the shaft section for placing timbers is done with pavement breakers and without blasting, thus securing exact dimensions and solid walls.

The above described method of shaft sinking permits the use of all waste from crosscuts, raises, and shaft enlargement for stope filling. Figure 4 is an elevation of the timber construction at the bottom of each shaft raise, where the waste is drawn out to be trammed to the stopes.

The winze from the 400 to the 500 foot level is a two-compartment 45° incline. Both compartments are 4 feet by 4 feet 6 inches. Timbers are 8 by 8 inch fir. The winze was sunk using a self-dumping, lugged bucket sliding on 6 by 6 inch skids. After sinking was finished 16-pound rails were laid on the skids, and a skip was installed. Winze-sinking rounds were drilled with hand-held hammer drills. Blasting was done with 35 per cent strength gelatin dynamite, No. 6 caps, and fuse, using seventy-five 1 by 8 inch cartridges per round. Primers were treated with a cap-sealing compound, and very few missed holes occurred. Water was handled with a two-stage centrifugal pump, direct-connected to a 10-horsepower electric motor. This pump proved much more satisfactory than an air-driven sinking pump. In sinking 170 feet the only maintenance work on the centrifugal consisted of cleaning the impellers once. When sinking was finished, the pump was relined and new impellers put in at a cost of only $130 for the new parts; the pump is now being used as a station pump on the 500 level.

Drifting and Raising

All drifts are driven 5 by 7 feet in section and are untimbered, the main levels being timbered when silled out preparatory to stoping. Drilling is done with hand-held hammer drills, supported by a ring-hook. The hook fits under the side-rod of the machine, and the ring over the end of a length of jackhammer steel. A round consists of from 12 to 15 holes, and is blasted with 45 and 55, 1 by 8-inch sticks of 35 per cent strength gelatin dynamite. All drifting is done on contract, the price for drilling, blasting, and placing air and water lines being $1.75 per foot. The average rate of advance is 4 feet per shift. Shoveling in drifts is also done under contract, at the standard rate, including laying track, of $1.50 per foot. When the tramming distance is too long, two muckers are used, and the rate is changed to $1 to $1.25 per man per foot.

The average raise is 4 by 7 feet in section. Chutes are not generally used in raising, the broken material falling on a platform at the foot of the raise, from where it is shoveled by hand into cars. This is done to avoid the accumulation of gas from blasting which is held back in a raise closed by a chute. All raises are driven on contract. The price for untimbered raises is $1.75 per foot, which includes drilling, blasting, and placing stulls for platforms.

Drilling equipment in the mine consists of several makes of hand-held hammer drills and of stoper drills. The former use 7/8-inch hollow hexagonal steel with jackhammer shanks, and the latter, use 1-inch quarter octagon hollow steel. All machines are equipped for drilling wet, but very few of the miners will use water in the stoper machines, except in wet raises where it is difficult to drill dry. All working places are piped with air and water lines supported near the back from timbers or plugs in the rock. Two-inch pipe is used for main air lines and 1-inch for branches. Water lines are of ½-inch pipe. All pipe is cut in 10-foot lengths, which is more satisfactory than the usual longer lengths, particularly where the contractors have to install their own lines.

Stoping

Where the vein is narrow the ore is mined and the stopes filled, using very little timber. Where the vein is wide square-set and filled stopes are used.

In either case, stoping is started on the main level by mining out the full width of the ore and placing 10 by 10 inch floor sills from wall to wall at 5-foot intervals. Double 2-inch flooring is laid on these sills. In ore over 10 feet wide square-sets are placed on the sills. All square-sets are 5 feet square and 7 feet high and consist of 8 by 8 inch posts and caps and 6 by 8 inch ties. If the vein is less than 10 feet wide, drift sets are stood on the floor sills, the caps of which extend from wall to wall. The cap is supported on the hanging wall side by a batter post, and on the footwall side by a vertical post. When the sill is finished the first floor above is taken out and timbered with square-sets. The sill floor is then filled except such sets as are left for the track. These are lagged with double 2-inch plank to keep out the fill. The stulled raises on 50-foot centers are now enlarged and timbered with square-sets, one set wide from footwall to hanging wall. The two methods of stoping are alike to this point.

Formerly flat-backed or horizontal filled stopes were used in narrow stopes. The raises served as fill raises above the stope and as ore chutes below. Trouble was experienced because of caving of the ore and wall rock. Horizontal slips entering from the hanging wall cut the ore at about 6-foot intervals. Often, when a slice was finished and ready for the fill, the ore would cave to the next slip above, bringing down much hanging-wall waste with it. This made stoping dangerous, especially for the shoveler who had to wheel the ore through the stope to the chute.

To eliminate this danger and to be able to fill closer to the back, this method of stoping was abandoned in favor of rill stoping. A rill stope is started by stoping next to the center raise of a block as high as possible, then running in fill through the fill raise to its natural angle of repose. Floor is laid on the fill, a 3-foot inclined cut is taken out, and is followed by another fill. This process is repeated until the toe of the slope is within about 10 feet of the chute, after which the length of the slide is no further increased and the level space is maintained next to the chute during subsequent stoping operations for a shoveling floor. Most of the ore broken on the rill slides down to this floor where it can be sorted. The mill ore is shoveled into the chute, the waste is transferred to the adjoining section on the other side of the chute, and clean galena ore is stored on the platform until enough is on hand to justify cleaning the chute and sending it out of the mine. In filling a slice as little room is left under the back as possible. Mining starts at the bottom of the slide and advances upward.

With this system it has been possible to hold the slabs of ore better. In a single cut up the incline more slips are exposed, but each for only a short distance. In addition, while the shoveling platform offers the same facilities for sorting as a flat-backed stope, the shoveler works in only one place, where he can be protected by timbers if necessary. The ore runs by gravity toward the chute, and the fill spreads itself almost entirely without assistance.

In wide portions of the vein the sill floor is taken out and square-sets introduced the width of the vein. The first floor above is then stoped and timbered with sets, after which the raises are widened and timbered one set wide across the vein and up to the level above. Starting at the center raise of a 100-foot block on the second floor above the sill floor, three lines of sets are taken out on both sides of the raise and from wall to wall. On the third floor two lines are taken out in a similar manner, and on the fourth floor, one line is removed on both sides of the raise. This forms a pyramid of open ground with the raise at its center. Waste is next run in through the raise and the open ground filled as close to the ore as possible, after which a floor is laid on the fill. Stoping is now continued on either side of the raise as desired, until the toe of the rill is within 10 feet of the next chute, after which the last two sets are carried flat to furnish a shoveling platform where sorting can be done. Figure 5 illustrates this method of stoping at several different stages.

The original center raise could be filled, but the present practice is to lag off one set to serve as a chute for future use in passing waste to the lower levels. It also is used for a manway and pipe lines. Owing to the use of a shoveling platform at the foot of the incline no grizzlies are used over the chutes. The tops of the chutes are partly covered to prevent men falling into them. The ore is so heavy that sets must be placed as soon as the ground is out to prevent the caving of large blocks. Little drilling and blasting are required, as a very few holes will make room for a set. Drilling is done with both stopers and hammer drills. There is very little secondary blasting in the stopes, as large boulders are broken with hammers.

A stoping crew consists of a miner, a timberman, and a helper who work together at whatever is to be done. Formerly the miner took out the ground and a crew of timbermen followed. It was found, however, that at times the miner got far ahead of the timbermen and too much ground was left open, causing accidents.

Underground Transportation

Chutes with two wooden gates are used throughout the mine; one gate controls the flow of ore and the other is a stop gate. As an exception an iron hinged gate has been installed at the chute under the winze pocket on the 400 level and is giving satisfaction. This type of gate stops the run of fine material and in the future will be used on all important chutes. Two of these gates, made of old worn turn-sheet have been in use on the surface ore bin; 50,000 tons of ore has been loaded through them without repair to the gates.

All ore is trammed by hand in 14.5 cubic foot roller-bearing cars. The track is of 16-pound rails laid to 18-inch gauge on 3 by 6 inch fir ties. The average length of tram on the 400 level is 700 feet. Two trammers handle 100 cars per shift when there is no interference from handling timber. The present shaft station is small and floored with turn-sheets. The stations in the new shaft will have double track approaches.

The main shaft is served by a 35-horsepower, electric, single-drum hoist. This is an old steam hoist which has been converted to electric drive. Hoisting speed is 240 feet per minute. The cage is balanced by a counterweight which runs in the manway compartment and is connected to the cage (fig. 6). The ore load is about 1,800 pounds, and the unbalanced load on the hoist is about 400 pounds, just enough to give brake control. An average of 90 cars of ore is hoisted per shift. At times as much as 100 cars is hoisted, but this is the maximum possible, with men and supplies to be handled as well.

The new shaft will have three compartments, two for hoisting, 4 feet by 5 feet in section, and a manway and pipe compartment 3 feet by 5 feet. Hoisting will be done with single-deck cages operated in balance. This method is preferred to skip hoisting because of having to handle several classes of ore, and because of having to transfer waste from level to level underground.

The winze from the 400 to the 500 foot level is equipped with a self-dumping 10-cubic-foot skip and a 10-horsepower electric hoist. This handles up to 180 skips per shift, in addition to some supplies. The labor cost of the work is $8.50 per shift for hoistman and skip-tender.

PER CENT EXTRACTION

In mining by a method requiring filling it is not practical to leave ore for future stoping. Some copper ore has been left on the 500 level, but in such shape that it can be mined when the necessary hoisting facilities are obtained.

Up to the present 100 per cent extraction has been made in all blocks worked. Considerable sorting is done underground as this improves the grade and furnishes some of the waste needed for fill. Possibly 3 per cent of the amount broken is sorted out underground. On the surface the ore is dumped over inclined grizzlies, and the oversize passed over sorting tables at the foot of the grizzlies. About 5 per cent is sorted out here, at a cost of $2 per ton of waste. The present cost of transportation and treatment is about $6 per ton, so that a very substantial saving is accomplished. In the sorting at the surface all the clean galena ore possible is taken out, amounting to about 30 tons per month of galena assaying about 65 per cent lead and with very little zinc.

WAGES, CONTRACT AND BONUS SYSTEM

The labor in this district is mostly Mexican, some American-born, but largely from Mexico. Of the new men employed about 50 per cent are inexperienced, but after five years of operation some very good miners have been trained. The turnover is small. Americans are employed when available, but do not exceed 15 per cent of the total payroll.

The following wage scale is in effect (February, 1930).

Timbermen	$ 4.50 to 5.00	according to ability
Timbermen helpers	4.00	
Machinemen	4.25	in stopes
Machinemen	5.00	on wet sills
Muckers	3.35	in stopes
Muckers	4.00	on wet sills
Trammers	3.00	and bonus
Cagers	3.50	and bonus
Top landers	3.50	and bonus
Tram bosses	4.25	
Hoistmen on surface	5.00	
Hoistmen underground	4.50	
Pipemen	5.00	
Timber framers	5.50	
Carpenters	7.00	
Blacksmiths	5.50	

All drifts, crosscuts, and raises are driven on contract as previously described. The contractors are chosen from the crew, giving consideration to length of time employed, ability, and reliability. Tramming and hoisting ore are on bonus, so planned as to obtain good cooperation from all concerned. The tram boss loads the cars and has charge of the tramming. His rate is $4.25 per shift, plus 1 cent per car hoisted. The two trammers are paid $3 per shift each, plus 2 cents each per car hoisted. The cager receives $3.50 plus 2 cents for each car, and the top-lander $3.50 plus 1 cent per car hoisted. The result is that each man is interested in getting the ore to the surface and they are willing to help each other. To avoid one shift's taking advantage of the next the bonus for the two shifts each day is the same, and is based on the cars hoisted during the two shifts. This system has operated satisfactorily for over 20 months. The trammers tire of the job after several months steady work and are changed to other work for a short time, after which they return to tramming.

VENTILATION, DRAINAGE, AND SANITATION

The mine workings south of the main shaft are connected on the 300 and 400 foot levels with the Lucky Bill mine. This affords a natural ventilation that has been of value in work north of the shaft. In driving north on the 300 and 400 levels it has been possible to get good air conditions by connecting the two levels by raises. In cold weather the Ground Hog shaft is upcast and is reversed in warm weather. At present all the north end workings are connected to the North Shaft raise, and the natural ventilation is good. In driving headings beyond the reach of this natural ventilation, electric blowers and vent-tube are used.

The accumulation of considerable water during work on the sill presented a drainage problem in driving the 500 level down-grade to connect with the new shaft. A 5-horsepower vertical centrifugal electric pump was installed, known as an "Electric Sponge." This is placed wherever work is being done, to force the water out to the pump at the foot of the incline. When no sills are being placed, a shallow sump is made and the "Sponge" placed over it.

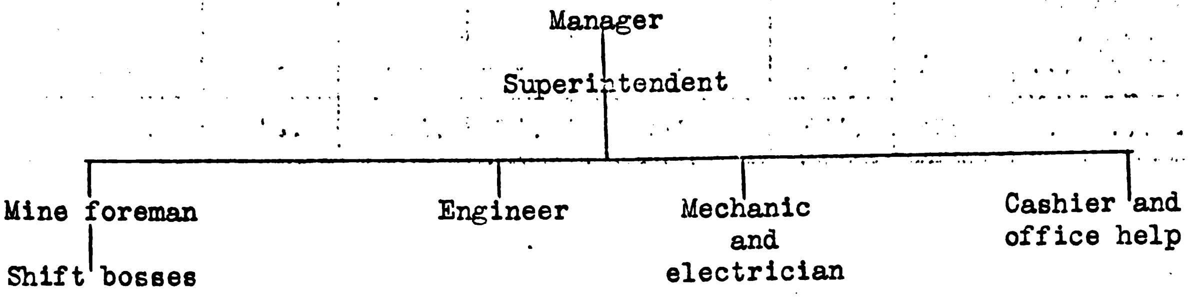
Latrine cars have solved a problem that was a serious nuisance. One car placed in a convenient place on the 400 level serves the entire mine. The car is charged with 25 gallons of water and 1 quart of soluble creosol compound, a strong deodorizer. Once a week the car is sealed and hoisted to the surface, a clean car being put in its place. On the surface the full car is flushed with water into a pit excavated in the dump.

FIRE PREVENTION, FIRST AID, MINE SAFETY, AND ORGANIZATION

All scrap wood, powder boxes, paper, and rubbish are sent out of the mine and an effort is made to keep the mine clean. No provisions have been made to fight fire underground, as the fire risk is considered very slight.

No safety organization is maintained. A few men on each shift have been trained in first aid. The foreman and shift bosses have very definite orders as to safety, and the men are cautioned about unsafe practices.

The organization of the mine force is as follows:



MINING COSTS

Table 1.--Summary of costs

Name of mine: Asarco Mining Co., Ground Hog mine. Period covered: Jan., Feb., Mar., 1930.

Tons of ore mined and hoisted during period: 11,146. Mining methods: Timbered rill.

Underground costs per ton of ore mined and hoisted

	Labor	Supervision	Compressed-air drills and steels	Power costs	Explosives	Timber	Other supplies	Total
Development								
In ore	.538	.033	.052	.034	.059	.118	.088	.922
In rock	.197	.020	.064	.040	.070	.080	- -	.471
Mining	1.197	.065	.053	.034	.058	.120	.235	1.762
Transportation (underground).	.542	- -	- -	.071	- -	- -	.015	.628
General underground expense	.080	- -	- -	- -	- -	- -	- -	.080
Surface expense (directly applicable to underground operation) ...	.121	- -	- -	- -	- -	- -	.006	.127
Total	2.675	.118	.169	.179	.187	.318	.344	3.990

Table 2.--Summary of costs in units of labor, power, and supplies

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Asarco Mining Company - Ground Hog mine. Period: Jan., Feb., Mar., 1930.
Tons of ore mined and hoisted: 11,146. Mining methods: Timbered rill.

A. Labor (man-hours per ton hoisted)

Breaking, timbering and mucking	
Development	1.328
Mining, including filling	2.140
Haulage and hoisting	1.005
Supervision	.158
General	.127
Total labor underground	4.758
Average tons per man shift underground	1.681
Average tons per man shift on surface properly chargeable to underground	4.111
Average tons per man shift, including surface	1.193
Labor, percentage of total cost	67.043
Supervision, percentage of total cost	2.957

B. Power and supplies

Explosives (lbs. per ton)	
Development	.27
Mining	.63
Timber (bd. ft. per ton)	
Development	2.97
Mining	5.15
Total power (kw.h. per ton) (Includes air compression, hoisting, pumping, ventilation, lighting and miscellaneous for which we have no meters for segregation of power consumption)	8.745
Other supplies in percentage of total supplies and power	40.33
Supplies and power, percentage of total cost	30.00

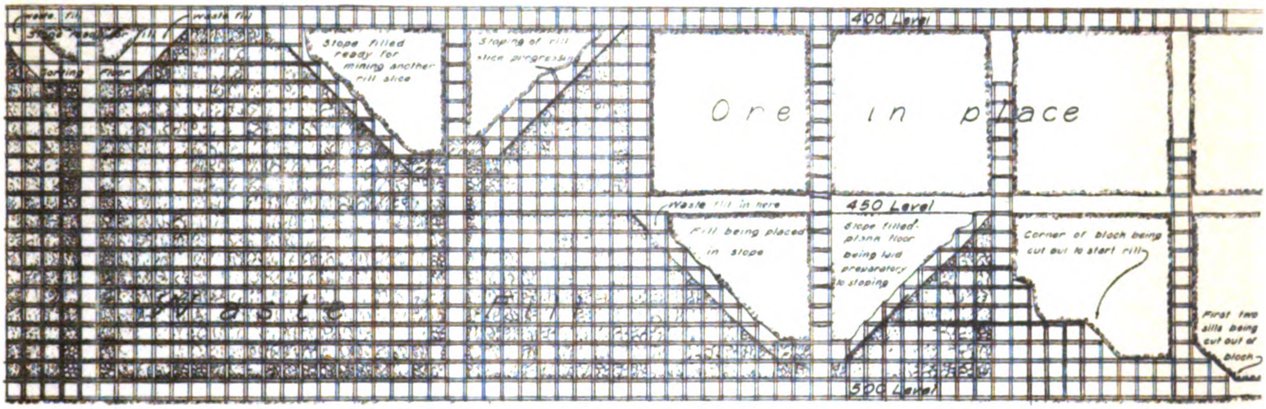
Waste fill
Stope ready for fill
Waste fill
Forming floor
Stope filled ready for mining another rill slice
Stoping of rill slice progressing
400 Level
Ore in place
Waste fill in here
Fill being placed in stope
450 Level
Stope filled plank floor being laid preparatory to stoping
Corner of block being cut out to start rill
First two sills being cut out of block
Waste fill
500 Level

Figure 5.- Square-set-and-fill method of stoping

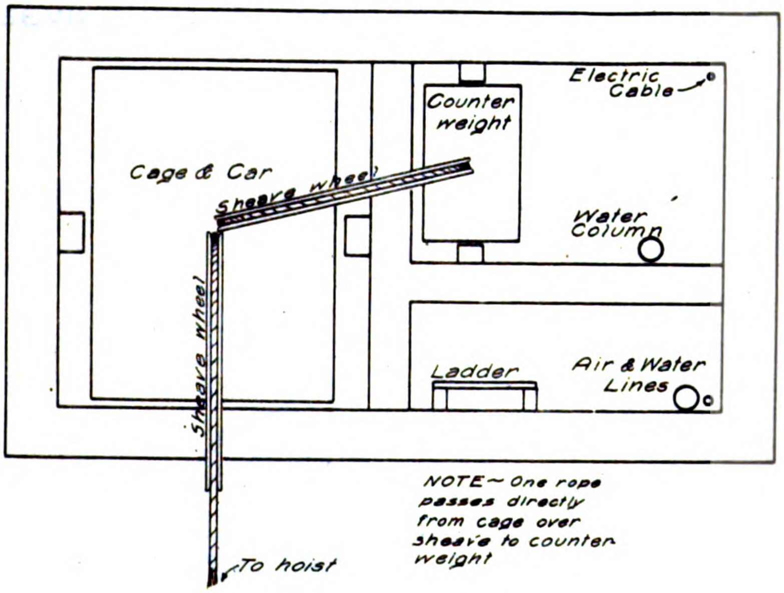

Figure 6.- Plan of present main Ground Hog shaft